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# Occupational and non-occupational factors of post-COVID-19 condition: a cross-sectional survey in the French general working population

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## ABSTRACT

**Introduction** Although the working population carries the greatest burden of long COVID, occupational and non-occupational factors of the condition have not yet been well documented in this population. The aim of this study was to investigate these factors.

**Methods** A nationwide random sampling cross-sectional survey was conducted among the adult population in mainland France after the large Omicron waves in the autumn of 2022. Post-COVID-19 condition (PCC) was defined according to the WHO. Associations of occupational and non-occupational factors with PCC were tested in a conceptual model accounting for the relationships between these factors and considering two control groups (previously infected participants without PCC and participants with no reported or diagnosed SARS-CoV-2 infection). Interactions between occupational and non-occupational factors were considered.

**Results** The survey included 1131 working adults. PCC was positively associated with reported infection while providing care (prevalence ratio (PR)=2.06 (95% CI 1.08 to 3.94)), being in contact with a colleague (PR=1.61 (95% CI 1.04 to 2.48)) and increased workload (PR=2.85 (95% CI 1.12 to 7.24)), whereas it was negatively associated with reported infection while being in contact with the public or clients (PR=0.23 (95% CI 0.07 to 0.76)). Several non-occupational factors were associated with PCC: sex, household size, household financial satisfaction, number of pre-existing chronic conditions, anxiety, injury sequelae and perceived SARS-CoV-2 infection severity. No interactions were found between these factors.

**Conclusions** Reducing the burden of long COVID in the working population requires public health strategies that consider a wide spectrum of factors, including work conditions in a broad sense. Specific attention should be given to the most vulnerable workers accumulating such factors.

### WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Although the heterogeneity of SARS-CoV-2 infection among the working population has been well described, occupational and non-occupational factors associated with long COVID are far less documented in this population, which carries the greatest burden of long COVID.

### WHAT THIS STUDY ADDS

⇒ This study highlights the role played by workplace SARS-CoV-2 infections and the deterioration of working conditions in the development of long COVID in the working population.
⇒ This study also points to the independent role of non-occupational factors prevalent in working subjects.

### HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The working age population is an important target of prevention strategies for long COVID while taking into account a wide spectrum of factors, including work conditions in a broad sense.
⇒ Workplaces may be an important setting for long COVID prevention and screening.
⇒ Specific attention should be given to the most vulnerable categories of workers.

## INTRODUCTION

Since the beginning of the COVID-19 crisis, many individuals who experienced SARS-CoV-2 infection reported lasting symptoms that impaired their daily functioning and quality of life.[1 2] This condition, referred to as 'long COVID'[3] but also called 'post-COVID-19 condition' (PCC),[4] 'persistent post-COVID'[5] or 'post-acute sequelae of COVID-19',[6] has been reported among 7%–30% of people with a history of probable or confirmed SARS-CoV-2 infection in the general population[7–9] (Note that in this paper, we employ the acronym 'PCC' in reference to the WHO's definition of 'post-COVID-19 condition'[4] and 'long COVID' in all other cases or as a generic term). Several population-based studies have shown that the condition is much more prevalent among young working adults, with this population responsible for more than two-thirds of PCC cases.[7 8] However, regarding the literature on factors associated with long

COVID (sociodemographic or health status, health behaviours and lifestyle, infection-related factors[10–12]), few studies to date have explored the role played by occupational factors in the development of long COVID.[13–16] Yet these factors may be linked to the context of SARS-CoV-2 infection, which is the necessary cause of the condition, or to the impact of the COVID-19 crisis on the professional situation of workers.

Growing evidence on working age populations suggests that public-facing workers[17–21] had a higher incidence of SARS-CoV-2 infection, among whom essential workers[22–25] were more likely to experience symptoms[26] that could plausibly lead to a higher risk of long COVID.[27] Furthermore, studies on the COVID-19 crisis and the impact of the successive lockdowns on working adults highlighted how these changes affected the professional situation and working conditions of workers during that period[28] and impacted their mental health,[15 29–32] especially increasing the risk of anxiety and depression, which were shown to predict the occurrence of long COVID.[33–35] In addition, population-based studies suggest that these health impacts were even more detrimental for those whose activity had been the most affected: younger adults, women and disadvantaged workers.[26 36–38]

Although multidimensional mechanisms are probably involved in the risk of long COVID among working individuals, no study to date has thoroughly and simultaneously explored the occupational and non-occupational (eg, socioeconomic and health) factors among this population and considered their interactions. We therefore aimed to assess these factors for PCC in working adults in a nationwide random sampling survey. The study, conducted in France after the large Omicron waves in autumn 2022, which involved the majority of PCC cases during that period,[8] uses two control groups: (1) previously infected participants without PCC according to the standard paradigm of PCC as a specific complication of SARS-CoV-2 infection and (2) participants never infected with SARS-CoV-2 (more accurately, those with no reported or diagnosed infection) according to the alternative paradigm of PCC as a condition potentially arising from causes other than SARS-CoV-2 infection. This study also examined associations of PCC with factors categorised according to a conceptual model accounting for the relationships between occupational and non-occupational factors.

## METHODS

### Survey stages and data collection

Between 2 September and 31 December 2022, 10 615 participants aged≥18 years and living in mainland France were selected using a standard sampling method based on the random digit dialling of landline and mobile telephone numbers (online supplemental figure 1; details given in Coste *et al*[8]). At first, they were all interviewed by telephone using the computer-assisted telephone interviewing (CATI) system. Data were collected on socioeconomic characteristics, previous SARS-CoV-2 infections and current symptoms (from a list of 31 systems; see online supplemental table 1), with details collected about the date of onset, alternative diagnoses and impact on daily functioning. Participants also gave their overall perception about having had long COVID. Second, three subsamples of participants were invited to continue the survey on an online platform (computer-aided web interview (CAWI)) to collect detailed information about their pre-existing chronic conditions, health behaviours (smoking, alcohol use and physical activity), vaccination, healthcare use in the past 12 months, social support and impact of the COVID-19 pandemic on their income, professional situation and social life. To ensure an adequate sample size (>150) in each group (at the whole population level), the sampling ratio was set to 1.0 for participants with PCC or perceived long COVID, 2.0 for those reporting SARS-CoV-2 infection without PCC or perceived long COVID and 5.7 for those reporting no infection.

A total of 1813 participants completed the detailed interview (CAWI) with a response rate of 43%, which was similar across the three groups (online supplemental figure 1). Only working adults who were gainfully employed or job seekers during the past 12 months were retained for this study (figure 1).

### Ascertainment of PCC

The standard PCC definition was used[4 7 8] based on the following criteria:

1. Having at least one 'qualifying' symptom from the list of 31 (online supplemental table 1); for which the symptom(s):
2. Appeared within 3 months of a probable SARS-CoV-2 infection.
3. Lasted for at least 2 months.
4. Had an impact (even low) on daily functioning.
5. Could not be explained by an alternative diagnosis (according to a physician).

Five common clinical PCC 'phenotypes' were distinguished according to the presence of qualifying symptoms (fatigue, musculoskeletal, psychiatric, cardiopulmonary and neurological symptoms; Online supplemental table 1).

### Occupational and non-occupational factors

The following information was recorded for all CAWI participants:

1. 'Structural' occupational characteristics: occupation, employer, employment status and household income at the time of the interview.
2. Context of SARS-COV-2 infection in the workplace: sector specific (in contact with children or students, with the public or clients and while providing patient care) and cross-sectorial (from a colleague, in a catering place, in precarious employment and in self-employment), as evaluated by the participant in

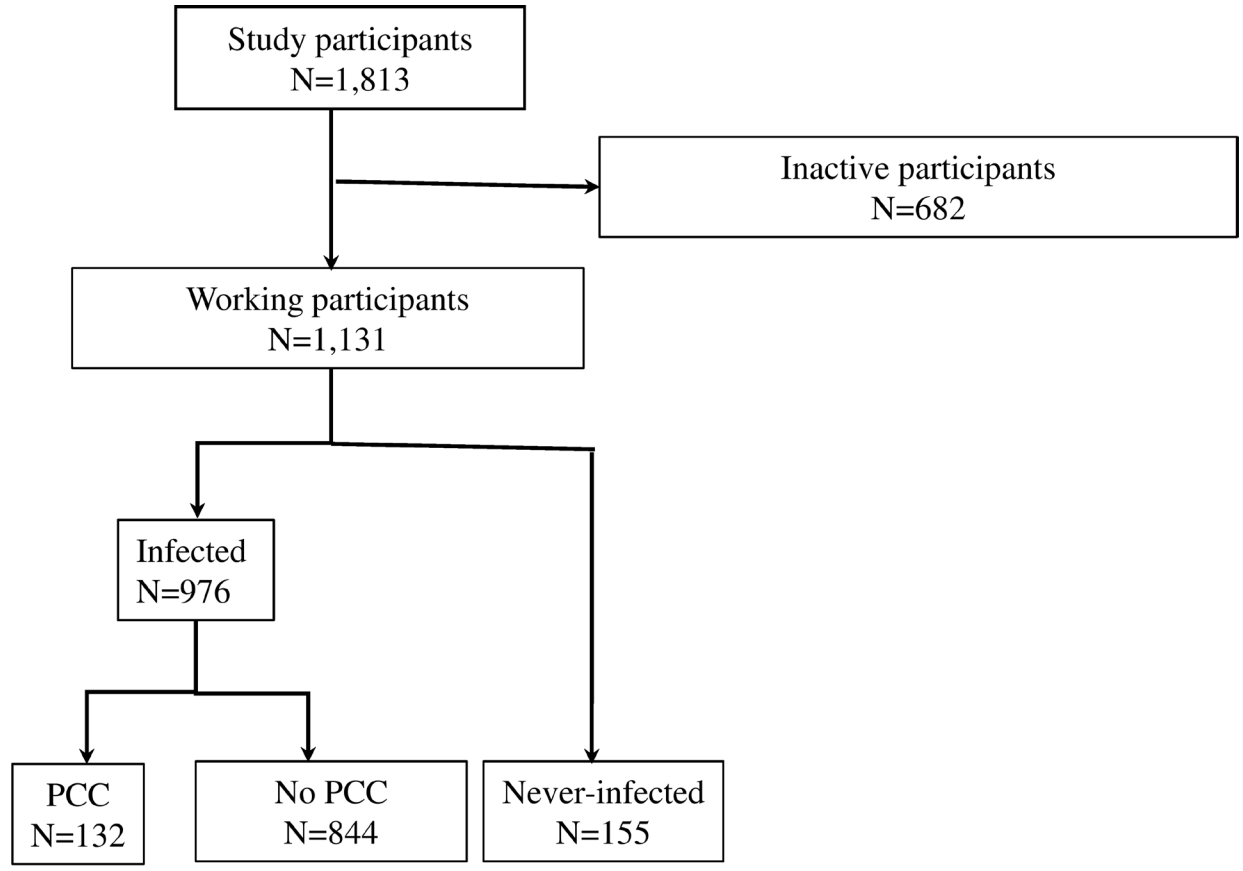


**Figure 1** Flow chart of the study. PCC: post-COVID-19 condition based on the World Health Organisation's definition.

a multiple-choice question about the contexts of infection using these exact terms.

3. COVID-19-crisis-related occupational impacts: job loss, change of job, worsened working conditions and other impacts on activity and work conditions between March 2020 and the interview.

Comprehensive data collection also included sociodemographic, health status, health behaviours and healthcare interactions, socioeconomic features and evolutions as well as SARS-CoV-2 infection factors. The Minimum European Health Module (MEHM) was used to assess self-perceived health and activity limitations.[39]

### A conceptual model of risk factors of PCC among working participants

A conceptual model was further constructed with the aim: (1) to define relevant sets of potential risk factors or determinants, whether occupational or not, and the main relationships between these sets and (2) to identify, on the one hand, the minimal set of covariates to be adjusted for each given set of potential risk factors and, on the other hand, to discard covariates likely to be intermediates and for which, if controlled for, would lead to an overadjustment. Five sets of risk factors (figure 2) operating in a chronological and potential causal order were thus distinguished:

1. Basic and early defined sociodemographic characteristics: age, sex, geographic origin and education level.
2. Health status: physical and mental comorbidities diagnosed by a physician and experienced during the last 12 months, including the number of diseases, mental diseases (anxiety, depression) and physical diseases (low back pain, injury sequelae).
3. Health behaviours and healthcare: alcohol consumption, daily smoking, SARS-CoV-2 vaccination from March 2021, number of general practitioner consultations and number of specialist consultations during the last year.
4. Socioeconomic situation and work conditions: household size, household income, household financial satisfaction, occupational characteristics and COVID-19-crisis-related occupational impacts as detailed above.
5. SARS-CoV-2 infection history: number of infections from January 2020, occupational circumstances (as detailed above), COVID-19-related hospitalisation and perceptive experience of COVID-19 and long COVID.

Note that the second, third and fourth sets should be tested simultaneously, since no order of preference can be firmly established due to the bidirectional relationships between factors in these sets. Reverse causal pathways between PCC and factors in these latter sets are possible but less likely within the relatively short period considered here. For this reason, they have not been taken into account.

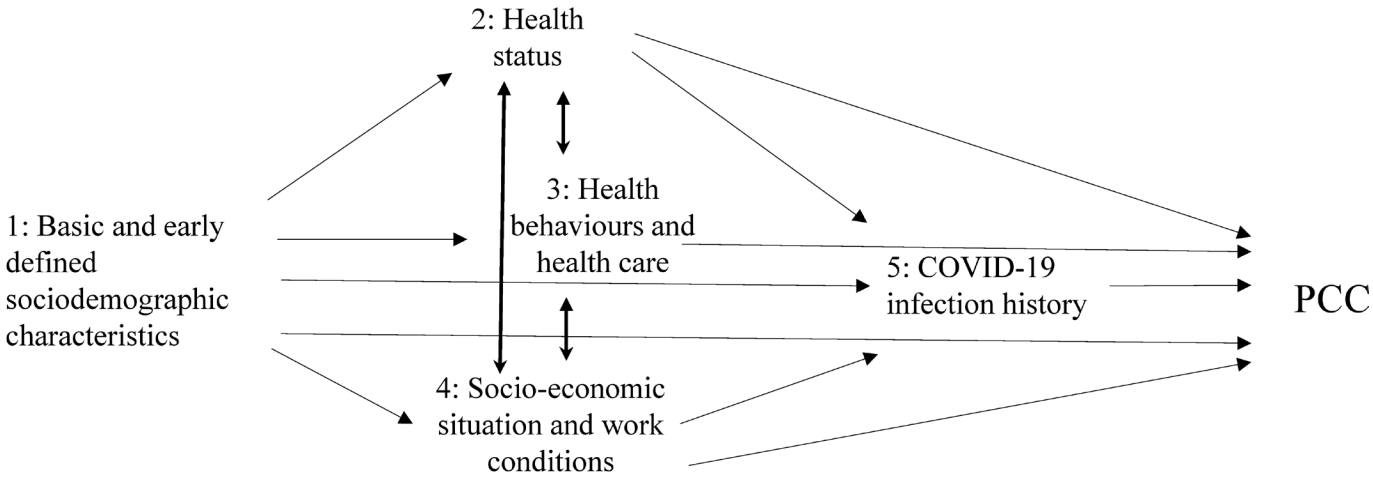


**Figure 2** Conceptual model of risk factors for PCC among the working population. PCC: post-COVID-19 condition based on the World Health Organisation's definition.

### Statistical analysis

Descriptive statistics were used to assess the prevalence of risk factors across comparison groups (PCC, infected and never infected).

According to the conceptual model described above, each factor had to be tested while considering confounders related to the same set or to a preceding set in the potential causal pathway. Two series of Poisson regression with robust variance were constructed hierarchically to derive prevalence ratios (PRs) and 95% CIs of PCC while considering the two control groups (online supplemental figure 2): (1) previously infected participants without PCC according to the standard paradigm of PCC as a specific complication of SARS-CoV-2 infection and (2) never-infected (with no reported or diagnosed infection) participants according to the alternative paradigm of PCC as a condition potentially arising from causes other than SARS-CoV-2 infection.

In the first series, when comparing participants with PCC to those infected without PCC, four stages of modelling were undertaken: at stage 1, a simple model including only the factor to be tested with age and sex; at stage 2, a model including the preceding (only significantly associated) variables as well as comorbidities and health status variables; at stage 3, a model including the preceding variables and living conditions; at stage 4, a model including the preceding variables and SARS-CoV-2 infection history.

In the second series, when comparing participants with PCC to never-infected participants, two stages were distinguished: at stage 1, a simple model including only the factor to be tested with age and sex; at stage 2, a model including the preceding variables in addition to health status and comorbidities, health behaviours and living conditions.

Only statistically significant factors at a given stage (ie, significantly associated with PCC) were considered as a potential explanatory variable at the following stage. Final models included all variables associated with PCC after stage 4 and stage 2 for comparisons with participants infected without PCC and never-infected participants, respectively.

Interactions (based on departures from the multiplicative Poisson model used[40]) were tested between factors significantly associated with PCC in the final models.

In addition, qualifying symptoms and MEHM indicators were described and compared across SARS-CoV-2 waves, while risk factor profiles and MEHM indicators were described across the main PCC clinical phenotypes.

Percentages and PRs were weighted to take into account the selection probability of participants (online supplemental figure 1) and to represent the French population structure according to age, sex, educational level, region of residence and level of urbanisation. Type 1 error was set at 0.05 (two sided). SAS V.9.2 software was used.

### Patient and public involvement

Due to the aim and scope of this study, it was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of the research.

## RESULTS

### Study population

This study included 1131 participants (figure 1). Participant characteristics according to the main study groups (PCC, non-PCC infected and never-infected) are provided in table 1 and online supplemental table 2 along with PRs according to the models obtained at each stage. Final models for occupational and non-occupational factors are reported in table 2 for each comparison group. Online supplemental table 1 summarises PCC cases with regard to symptoms meeting the standard WHO-PCC definition ('qualifying' symptoms), self-perceived health and limitation, as well as overall and according to SARS-CoV-2 waves of occurrence. Online supplemental table 3 describes the main characteristics of participants along with their main occupational features (structural and occupational infections as

**Table 1** Adjusted prevalence ratios (PRs) for occupational factors for post-COVID-19 condition (PCC) according to the different models

| | PRs of PCC (95% CI) | | | | | |
|---|---|---|---|---|---|---|
| | Comparison versus infected non-PCC* | | | | Comparison versus non-infected† | |
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 1 | Stage 2 |
| Feature | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) |
| A. Structural occupational features | | | | | | |
| Occupation | | | | | | |
| Company manager, entrepreneur | 0.89 (0.42 to 0.1.87) | | | | 1.04 (0.41 to 2.60) | |
| Senior manager, professional | 1 (ref) | | | | 1 (ref) | |
| Middle manager, teacher | 0.86 (0.49 to 0.1.53) | | | | 0.96 (0.48 to 1.92) | |
| Office employee | 1.27 (0.85 to 0.1.90) | | | | 0.90 (0.53 to 1.50) | |
| Manual worker | 1.73 (0.66 to 4.52) | | | | 0.90 (0.28 to 2.90) | |
| Employer | | | | | | |
| Public employer | 1 (ref) | | | | 1 (ref) | |
| Private employer | 0.99 (0.67 to 1.47) | | | | 0.78 (0.47 to 1.30) | |
| Self-employed | 0.70 (0.38 to 1.30) | | | | 0.86 (0.40 to 1.87) | |
| Other | 1.19 (0.57 to 2.51) | | | | 0.65 (0.26 to 1.58) | |
| Household income | | | | | | |
| First tertile | 0.90 (0.48 to 1.68) | | | | 0.51 (0.24 to 1.09) | |
| Second tertile | 1 (ref) | | | | 1 (ref) | |
| Third tertile | 1.00 (0.68 to 1.47) | | | | 1.24 (0.77 to 2.00) | |
| Not reported | 1.67 (0.75 to 3.73) | | | | 0.78 (0.28 to 2.13) | |
| Employment status | | | | | | |
| Paid employment | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Unemployed | 1.23 (0.61 to 2.48) | 1.00 (0.49 to 2.04) | 0.92 (0.46 to 1.86) | 0.97 (0.49 to 1.92) | 0.75 (0.33 to 1.73) | 0.76 (0.36 to 1.59) |
| B. Context of SARS-CoV-2 infection in the workplace | | | | | | |
| Infection with SARS-CoV-2 in the workplace | | | | | | |
| Yes | 1.22 (0.85 to 1.77) | 1.16 (0.81 to 1.68) | 1.17 (0.81 to 1.68) | 1.04 (0.72 to 1.50) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while in contact with children or students | | | | | | |
| Yes | 0.93 (0.49 to 1.78) | 0.99 (0.52 to 1.87) | 0.98 (0.52 to 1.86) | 0.79 (0.41 to 1.55) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while in contact with clients or public | | | | | | |

Continued

**Table 1** Continued

| Feature | PRs of PCC (95% CI) | | | | | |
|---|---|---|---|---|---|---|
| | Comparison versus infected non-PCC* | | | | Comparison versus non-infected† | |
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 1 | Stage 2 |
| | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) |
| Yes | **0.25 (0.08 to 0.83)** | **0.23 (0.07 to 0.74)** | **0.22 (0.07 to 0.71)** | **0.22 (0.07 to 0.72)** | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while providing patient care | | | | | | |
| Yes | **2.52 (1.36 to 4.67)** | **2.17 (1.16 to 4.07)** | **2.14 (1.16 to 3.92)** | 1.82 (0.98 to 3.36) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while in contact with a colleague | | | | | | |
| Yes | 1.45 (0.94 to 2.26) | 1.52 (0.99 to 2.35) | **1.59 (1.03 to 2.45)** | 1.48 (0.97 to 2.25) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection in an eating place | | | | | | |
| Yes | 0.92 (0.29 to 2.89) | 0.82 (0.26 to 2.58) | 0.86 (0.28 to 2.68) | 0.87 (0.28 to 2.77) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while in precarious employment | | | | | | |
| Yes | 1.32 (0.76 to 2.28) | 1.30 (0.74 to 2.28) | 1.29 (0.74 to 2.25) | 1.22 (0.70 to 2.12) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| Infection while in self-employment | | | | | | |
| Yes | 0.62 (0.19 to 2.06) | 0.66 (0.19 to 2.28) | 0.67 (0.20 to 2.29) | 0.66 (0.19 to 2.23) | | |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | | |
| C. COVID-19 related occupational evolutions | | | | | | |
| Impact of COVID-19 crisis on occupation and work conditions | | | | | | |
| Yes | **1.54 (1.05 to 2.25)** | 1.35 (0.93 to 1.98) | 1.34 (0.91 to 1.97) | 1.30 (0.88 to 1.91) | 1.54 (0.97 to 2.44) | 0.95 (0.60 to 1.48) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Job loss | | | | | | |
| Yes | 1.06 (0.46 to 2.44.) | 0.90 (0.40 to 2.05) | 0.79 (0.33 to 1.88) | 0.75 (0.32 to 1.79) | 1.49 (0.52 to 4.24) | 0.84 (0.35 to 2.04) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Change of job | | | | | | |
| Yes | 1.10 (0.63 to 1.92) | 0.90 (0.51 to 2.58) | 0.90 (0.51 to 1.59) | 0.87 (0.49 to 1.55) | 1.33 (0.63 to 2.79) | 1.43 (0.80 to 2.56) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |

Continued

**Table 1** Continued

| Feature | PRs of PCC (95% CI) | | | | | |
|---|---|---|---|---|---|---|
| | Comparison versus infected non-PCC* | | | | Comparison versus non-infected† | |
| | Stage 1 | Stage 2 | Stage 3 | Stage 4 | Stage 1 | Stage 2 |
| | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) | PR (95% CI) |
| Worsened working conditions | | | | | | |
| Yes | **1.55 (1.05 to 2.27)** | 1.30 (0.90 to 1.88) | 1.29 (0.89 to 1.86) | 1.22 (0.84 to 1.77) | 1.29 (0.82 to 2.04) | 0.81 (0.53 to 1.25) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Other occupational impact(s)‡ | | | | | | |
| Yes | 1.29 (0.88 to 1.90) | 1.36 (0.93 to 1.97) | 1.36 (0.94 to 1.98) | 1.36 (0.94 to 1.98) | **1.67 (1.04 to 2.69)** | 1.37 (0.90 to 2.07) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Organisational changes | | | | | | |
| Yes | 0.43 (0.18 to 1.06) | 0.48 (0.19 to 1.20) | 0.50 (0.20 to 1.26) | 0.51 (0.20 to 1.29) | 0.44 (0.15 to 1.31) | 0.94 (0.33 to 2.64) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Workload increase | | | | | | |
| Yes | 1.10 (0.44 to 2.74) | 1.44 (0.56 to 3.72) | 1.57 (0.61 to 4.04) | 1.72 (0.68 to 4.34) | 1.57 (0.55 to 4.46) | **2.85 (1.12 to 7.24)** |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |
| Impacted economic activity | | | | | | |
| Yes | 1.46 (0.71 to 3.03) | 1.50 (0.77 to 2.93) | 1.45 (0.74 to 2.85) | 1.43 (0.75 to 2.72) | 2.08 (0.85 to 5.11) | 1.00 (0.58 to 1.73) |
| No | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) | 1 (ref) |

Bold values indicate statistically significant values.
*Stage 1: age and sex adjusted; Stage 2: stage 1 factors plus number of chronic diseases and anxiety; Stage 3: stage 2 factors plus household financial satisfaction; Stage 4: stage 3 factors plus number of SARS-Cov-2 infections and perceived COVID-19 severity.
†Stage 1: age and sex adjusted; Stage 2: stage 1 factors plus household size, number of chronic diseases, anxiety, physical injury, vaccination status and perception of long COVID.
‡Participants who answered this question positively could also add a written explanation; the next three impact variables were constructed after analysing the answers obtained (mainly increased remote work, increased workload or impacted activity).

**Table 2** Adjusted prevalence ratios (PRs) for post-COVID-19 condition (PCC)

| | Final models | |
|---|---|---|
| | Versus infected non-PCC | Versus never infected |
| Factor | PR (95% CI) | PR (95% CI) |
| Sex | | |
| Male | 1 (ref) | 1 (ref) |
| Female | **1.55 (1.03 to 2.33)** | **1.85 (1.18 to 2.90)** |
| Age | | |
| 18–34 years | 1.02 (0.60 to 1.72) | 0.83 (0.48 to 1.45) |
| 35–44 years | 1 (ref) | 1 (ref) |
| 45–54 years | 1.10 (0.69 to 1.76) | 0.86 (0.51 to 1.48) |
| ≥55 years | 1.17 (0.70 to 1.97) | 0.63 (0.34 to 1.16) |
| Household size | | |
| 1 person | | **0.49 (0.25 to 0.97)** |
| ≥2 persons | | 1 (ref) |
| Household financial satisfaction | | |
| Yes | 1 (ref) | |
| No | **0.68 (0.48 to 0.97)** | |
| Number of individual chronic conditions | | |
| 0 | 1 (ref) | 1 (ref) |
| 1 | **2.17 (1.24 to 3.80)** | **1.86 (1.00 to 3.46)** |
| ≥2 | **3.38 (1.91 to 5.97)** | **3.55 (1.74 to 7.24)** |
| Anxiety | | |
| Yes | **1.64 (1.09 to 2.47)** | **2.98 (1.68 to 5.30)** |
| No | 1 (ref) | 1 (ref) |
| Injury sequelae | | |
| Yes | | **2.31 (1.08 to 4.91)** |
| No | | 1 (ref) |
| Vaccination status against SARS-CoV-2 | | |
| 0 or 1 dose | | 1 (ref) |
| ≥2 doses | | **0.42 (0.28 to 0.61)** |
| Perception of COVID-19 severity at the population level | | |
| 0 to 5/10 | 1 (ref) | |
| 6 to 10/10 | **1.72 (1.19 to 2.48)** | |
| Context of SARS-CoV-2 infection in the workplace | | |
| Infection while in contact with clients or public | | |
| Yes | **0.23 (0.07 to 0.76)** | |
| No | 1 (ref) | |
| Infection while providing patient care | | |
| Yes | **2.06 (1.08 to 3.94)** | |
| No | 1 (ref) | |
| Infection while in contact with a colleague | | |
| Yes | **1.61 (1.04 to 2.48)** | |
| No | 1 (ref) | |
| Impact of COVID-19 crisis on occupation and work conditions | | |
| Workload increase | | |
| Yes | | **2.85 (1.12 to 7.24)** |
| No | | 1 (ref) |

Final models including occupational and non-occupational factors for PCC.
Bold values indicate statistically significant values.

well as pandemic-related occupational impacts). Online supplemental table 4 describes PCC cases in terms of risk factors and impact according to the main clinical phenotypes.

Among the whole sample of participants, there were 643 (51%) women, 342 (28%) individuals aged 40–54 years, 97 (10%) foreigners or people from overseas French departments and 72 (7%) unemployed individuals. Overall, 64% of participants reported a probable SARS-CoV-2 infection, with 88% reporting a positive test; only 9 (<1%) participants were hospitalised for acute SARS-CoV-2 infection. A total of 132 participants met the PCC criteria, resulting in a prevalence of PCC of 5%, 844 (59%) had been infected with SARS-CoV-2 at least once but had not been diagnosed with PCC and 155 (36%) had no history of SARS-CoV-2 infection. The majority of PCC cases (58%) occurred after the start of the Omicron waves (table 1). These cases were less symptomatic overall, experiencing less joint pain, anxiety and paraesthesia than PCC associated with the earlier waves (online supplemental table 1).

### Occupational factors

No structural occupational characteristics (occupation, employer and employment status) were significantly associated with PCC (table 1). After basic age and sex adjustments as well as additional adjustments for financial satisfaction, health status and behaviour characteristics (stages 2 and 3), PCC was negatively associated with reported SARS-CoV-2 infection while working in contact with clients or the public (PR=0.22 (95% CI: 0.07 to 0.72)), and positively associated with reported SARS-CoV-2 infection while providing patient care (PR=2.14 (95% CI 1.16 to 3.92)) and while in contact with a colleague (PR=1.59 (95% CI 1.03 to 2.45)) (table 2). These associations remained in the final model (table 2) with PR=0.23 (95% CI 0.07 to 0.76), PR=2.06 (95% CI 1.08 to 3.94) and PR=1.61 (95% CI 1.04 to 2.48), respectively. The decreasing strength of the associations after additional adjustments and especially the number of SARS-CoV-2 infections (stage 4) points to the mediating effect of the latter.

Reporting any COVID-19 crisis impacts on occupation conditions (PR=1.54 (95% CI 1.05 to 2.25)) and, more specifically, experiencing poorer working conditions (PR=1.55 (95% CI 1.05 to 2.27)) was positively associated with PCC after basic age and sex adjustments when compared with infected participants without PCC (stage 1). After further adjustments, the associations slightly decreased. In the comparison with non-infected participants, 'other' occupational impacts (PR=1.67 (95% CI 1.04 to 2.69)) and especially increased workload (PR=2.85 (95% CI 1.12 to 7.24)) were associated with PCC, even after complete adjustments for living conditions, health status and health behaviour characteristics (stage 2) (tables 1 and 2).

### Non-occupational factors

Several non-occupational factors were significantly and independently associated with PCC in both comparisons: sex (female), number of pre-existing comorbidities and anxiety (table 2). Financial (dis)satisfaction and the perceived (high) severity of COVID-19 at the population level were positively associated with PCC when compared with infected non-PCC participants. Household size (≥2 people), injury sequelae and vaccination status (0 or 1 dose) were significantly and independently associated with PCC when compared with the never-infected group (table 2). Of note, age, education level, geographic origin, smoking and alcohol consumption were not significantly associated with PCC in either comparison (online supplemental table 2). Healthcare utilisation was no longer associated with PCC after adjusting for comorbidities (data not shown).

No clear risk pattern (either occupational or non-occupational factors) associated with the PCC 'phenotype' emerged (online supplemental table 4).

### Interactions between occupational and non-occupational factors

There was no significant interaction between any occupational factors and non-occupational factors retained in both final models.

## DISCUSSION

### Main findings

In this study of working adults conducted after the large Omicron waves of SARS-CoV-2 infections of 2022, after which 64% of this population group were infected and 5% met the PCC criteria, PCC was positively associated with infection while providing patient care, while being in contact with a colleague and having a worsened professional situation or working conditions during the COVID crisis, whereas infection while in contact with the public or clients was negatively associated with PCC. In addition, several non-occupational factors were also associated with PCC, especially female sex, household size, number of pre-existing chronic conditions, anxiety and injury sequelae (positive association) as well as vaccination status and financial satisfaction (negative association). No PCC phenotype appeared specific to any occupational or non-occupational factor, and no significant interaction between occupational and non-occupational factors was evidenced.

### Comparison with other studies: non-occupational factors

Sex, number of pre-existing comorbidities and pre-existing psychiatric disorders, especially anxiety, were found to be associated with PCC in this study as with long COVID in many previous studies.[7 8 12 33–35 41 42] However, age was not associated with PCC in this study contrary to other findings,[12] which may be due to the reduced age range of working individuals and our exclusion of older people (over 65 years) who generally present a lower risk of long COVID or

PCC.[7 8] Geographic origin was not associated with PCC contrary to the findings of a Swedish population-based study, which observed higher risks of both COVID-19 infection and persisting symptoms among workers with immigrant backgrounds.[43] Differences in the categorisation of this population group and low powered analysis due to the limited number of participants in this subgroup may explain this result. Our study also found a negative association of PCC with up-to-date COVID vaccination status in accordance with accumulating evidence.[44] However, no significant association was found with hospitalisations for COVID-19 contrary to earlier studies.[12] This may be due to the limited statistical power to detect associations with rare events, especially since the study was conducted after the large Omicron waves, also characterised by the lower incidence of severe SARS-CoV-2 infections and intensive care admissions in comparison with previous waves,[8 24 45 46] not to mention the protective effect of COVID vaccines that were widely adopted in France. The less symptomatic profile of PCC cases associated with the Omicron waves observed in this study is in line with this previous literature.

### Comparison with other studies: occupational factors

Structural occupational characteristics such as occupation, employer and employment status were not associated with PCC in contrast to household financial satisfaction, which was (negatively) associated with the condition. These findings support the hypothesis that the unfavourable financial context (possibly related to the socioeconomic impact of the COVID-19 crisis on employment status and working conditions in France[29]) could have increased the risk of PCC.

Among people infected with SARS-CoV-2, a positive association with PCC was observed when infection was reported while providing patient care. This is not surprising, since occupational settings specific to such activities necessitate contact with infected people, physical proximity to others and social aggregation during work,[17] thus increasing the risk of developing acute infection,[23 46 47] which is a necessary condition for developing long COVID and being hospitalised,[13 15 48] with the latter being a well-confirmed risk factor of long COVID.[12] A population-based cohort study conducted in the UK[23] found that among 'essential' professions (health, social and education workers, police and protective services), healthcare workers were the most vulnerable to severe COVID-19 relative to the other occupational groups. Repeated SARS-CoV-2 infections among healthcare workers may have mediated the risk of PCC, at least partly in our study, as evidenced by the reduced PR after adjusting for the number of SARS-CoV-2 infections and perception of COVID-19 severity. Although public-facing workers have been reported to have a higher risk of SARS-CoV-2 infections,[48] we found that infection reported while in contact with the public or clients was negatively associated with PCC. This result has not been previously reported, although a French study observed differences in symptomatic COVID-19 infections between 'essential' workers (often in contact with the public as mentioned above) and other in-person workers,[26] suggesting that these differences could be due to the frequency of testing, the requirement to keep working throughout the pandemic or the use of personal protective equipment (surgical masks, safety glasses, hand washing or sanitiser, plexiglass screens, etc), which was shown to provide effective[49] protection against SARS-CoV-2 infection. Although the latter probably merits confirmation, these findings generally confirm the idea that contextual factors should also be taken into account to better understand the burden of long COVID among workers in highly exposed occupational settings.

Changes in professional situation and, more specifically, poorer working conditions and increased workload during the pandemic were positively and consistently associated with PCC across the control groups in this study. Previous studies hypothesised that this could be caused by socioeconomic changes following the COVID-19 outbreak (job loss, burnout),[31 32] leading to mental health impairments.[50–55] The observation of worsened work ability following the onset of long COVID[15 56 57] cannot be excluded, although the majority of PCC cases in our study were associated with the Omicron waves[8] and were thus recent cases of long COVID.

### Study strengths and limitations

This study has several strengths. First, it is based on a large nationwide population-based random sample (with a satisfactory participation rate), which allows us to draw inferences in the general population setting. Second, the proportion of test-confirmed infections was very high at the time of the study, which used a comprehensive symptom assessment for PCC (date of onset, explanations by alternative diagnoses and impact on daily activities using a Likert scale for 31 symptoms allowing for the clinical phenotyping of PCCs), which was independent of the questions relating to exposure. Finally, the study adopted a structured epidemiological approach based on a conceptual model to comprehensively evaluate factors for long COVID according to two main paradigms for the condition as a specific SARS-CoV-2 complication and as a non-specific syndrome.

The study also has several limitations. First, the use of self-reported data and a relatively short list of professional contexts, activities and roles (in-person or remote) may have resulted in various misclassification errors and recall biases for earlier exposures to SARS-CoV-2 infection. In addition, the lower use of COVID-19 diagnostic tests among lower socioeconomical groups, already documented in France in 2020–2021,[58] may have introduced differential errors

regarding SARS-CoV-2 infection ascertainment, which could not be corrected (a problem reinforced by the high frequency of mild or asymptomatic infections with SARS-CoV-2[59]). However, the conduct of the interviews by experienced professionals, the blinding of participants to the precise objectives of the study relative to long COVID and the independent recording of the onset dates of SARS-CoV-2 infections and current symptoms probably minimised the risk of the most damaging differential errors. Second, the cross-sectional design limits the extent to which causal inferences can be made, although the unambiguous chronology of exposure to several factors and the various adjustments made with regard to this chronology probably made spurious causal inferences unlikely. Third, the exclusion of professionally inactive subjects at the time of the interview as opposed to the beginning of COVID-19 crisis possibly led to selection and misclassification biases. Finally, the statistical power was limited in detecting weak or even moderate associations in the case of rare events or categories (eg, COVID-19 hospitalisation, some socioeconomic variables such as foreign origin) or in comparisons with never-infected participants.

### Implications for clinicians and policymakers

More than 4 years since the initial reporting of cases, questions regarding the nature and causes of long COVID still remain.[60 61] Our study provides quantitative arguments reinforcing the view that aside from SARS-CoV-2 infection, preventive actions in occupational settings, notably among healthcare workers, as well as occupational health and general population policies should consider much broader multidimensional strategies, especially targeting workers with comorbidities, deteriorated working conditions and low financial security. These factors favour delayed recovery or maladjustment,[62] especially since two-thirds of adults with long COVID remain in active employment. Workplaces may therefore be an important setting to address such factors and to implement long COVID prevention and screening.

## CONCLUSION

This study conducted among a representative sample of working adults working in a broad diversity of occupations provides evidence that certain occupational characteristics may be risk factors for PCC, while it also highlights the combined effects of occupational and non-occupational factors of the condition. Reducing the burden of long COVID among the working population requires preventive actions that target SARS-CoV-2 infection in occupational settings in addition to broader policies that take into account contextual professional and socioeconomic changes and the complex array of underlying multidimensional mechanisms, particularly with regard to their effects on the most vulnerable categories of workers.

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**Patient and public involvement** Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

**Patient consent for publication** Not applicable.

**Ethics approval** This study involves human participants. The survey planning, conduct and reporting were in line with the Declaration of Helsinki. According to French law, this study did not have to obtain the approval of a national ethics committee because it relies only on the analysis of anonymously collected data. The survey was approved by the institutional review board of Santé Publique France, the French Public Health Agency, on 19 August 2022 (no ID). In accordance with the guidelines of the French Data Protection Authority (Commission Nationale de l'Informatique et des Libertés), all subjects included in this study were informed and gave oral consent to participate before the telephone interview. Data processing complied with the EU Data Protection Regulation 2016/679 (General Data Protection Regulation). Participants gave informed consent to participate in the study before taking part.

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